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CLASSIFICATION SCHEME FOR BENTHIC HABITATS:

MAIN EIGHT HAWAIIAN ISLANDS







NOAA National Ocean Service National Centers for Coastal Ocean Science Center for Coastal Monitoring and Assessment Biogeography Program

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DEVELOPED IN COOPERATION WITH FEDERAL, STATE, ACADEMIC, & PRIVATE SECTOR PARTNERS FOR THE DEVELOPMENT OF HAWAII DIGITAL BENTHIC HABITAT MAPS IN RESPONSE TO THE US CORAL REEF TASK FORCE NATIONAL ACTION PLAN

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ABOUT THIS DOCUMENT

This document was produced to support the U.S. Coral Reef Task Force (CRTF), created by Executive Order P.L. 13089, which calls for the conservation and protection of the nation's coral reefs. The *Classification Scheme for Benthic Habitats: Main Eight Hawaiian Islands* complements chapter one, Classification Scheme for Benthic Habitats, of the document *Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands*, (Kendall et al. 2001). Complementary schemes will be developed for the Northwest Hawaiian Islands and other US Territories and Commonwealths in the Pacific.

BACKGROUND

The National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) initiated a coral reef research program in 1999 to map, assess, inventory, and monitor U.S. coral reef ecosystems. These activities were implemented in response to requirements outlined in the *Mapping Implementation Plan* developed by the Mapping and Information Synthesis Working Group (MISWG) of the CRTF (MISWG 2000). As part of the MISWG of the CRTF, NOS' Biogeography Team has been charged with the development and implementation of a plan to produce comprehensive digital coral-reef ecosystem maps for all U.S. States, Territories, and Commonwealths within five to seven years. Joint activities between Federal agencies are particularly important to map, research, monitor, manage, and restore coral reef ecosystems. In response to the Executive Order, NOS is conducting research to digitally map biotic resources and coordinate a long-term monitoring program that can detect and predict change in U.S. coral reefs, and their associated habitats and biological communities.

Most U.S. coral reef resources have not been digitally mapped at a scale or resolution sufficient for assessment, monitoring, and/or research to support resource management. Thus, a large portion of NOS's coral reef research activities have focused on mapping of U.S. coral reef ecosystems. The map products will provide the fundamental spatial organizing framework to implement and integrate research programs and the capability to effectively communicate information and results to coral reef ecosystem managers. Although the NOS coral program is relatively young, it has had tremendous success in advancing towards the goal to protect, conserve, and enhance the health of U.S. coral reef ecosystems. One objective of the program was to create benthic habitat maps to support coral reef research to enable development of products that support management needs and questions. An initial step in producing benthic habitat maps is the development of a habitat classification scheme. The purpose of this document is to outline the benthic habitat classification scheme for the main eight Hawaiian Islands: Hawaii, Maui, Molokai, Lanai, Kahoolawe, Oahu, Kauai, Niihau.

This classification scheme will be used in the applied mapping component of the overall project. Benthic habitat maps will be created by visual interpretation of digital imagery using "heads up" (on screen) computer digitizing. The imagery must be of sufficient quality to enable visual interpretation into classified habitat maps. Regardless of the type of imagery collected (i.e., photographic, hyperspectral, satellite), it will need to be classified into distinct categories that meet the needs of both the management and scientific community. Developing this classification scheme is an important step in determining the type of map products to be produced from the imagery. To facilitate development of the digital benthic habitat maps, NOAA and its partners have produced a classification manual (*Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands*) that will document the specific methods used in image interpretation and habitat classification (Kendall et al. 2001). Chapters of the classification manual include a list of the classified habitats, description of the habitats, guidelines for on-screen mapping, and an assessment of classification accuracy.

Please continue to monitor the progress of this work on NCCOS's Biogeography Program website: (http://biogeo.nos.noaa.gov/)

DEVELOPING THE HABITAT CLASSIFICATION SCHEME

A hierarchical classification scheme was created to define and delineate habitats. The classification scheme was influenced by many factors including: requests from the management community, NOS's coral reef mapping experience in the Florida Keys and Caribbean, existing classification schemes for the Pacific and Hawaiian Islands (State of Hawaii 1981; Holthus and Maragos 1995; Gulko 1998; Allee et al. unpublished), other coral reef systems (Kruer 1995; Reid and Kruer 1998; Lindeman et al. 1998; Shepard et al. 1995; Vierros 1997; Chauvaud et al. 1998; Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute and NOAA, 1998; Mumby et al. 1998; NOAA et al. 1998), quantitative habitat data for the Hawaiian Islands, the minimum mapping unit (MMU - 1 acre for visual photointerpretation), and analysis of the spatial and spectral limitations of aerial photography and hyperspectral imagery. The hierarchical scheme allows users to expand or collapse the thematic detail of the resulting map to suit their needs. This is an important aspect of the scheme as it will provide a "common language" to compare and contrast digital maps developed from complementary remote sensing platforms. Furthermore, it is encouraged that additional hierarchical categories be added in the resulting geographic information system by users with more detailed knowledge or data for specific areas. For example, habitat polygons smaller than the MMU can be delineated, such as reef holes found in parts of the Hawaiian Islands, or habitat polygons delineated as colonized pavement using this scheme could be further attributed with health information (i.e., bleached, percent live cover) or species composition (i.e., Porites, Montipora).

GENERAL DESCRIPTION OF THE CLASSIFICATION SCHEME

The classification scheme defines benthic communities on the basis of two attributes: large geographic "zones" which are composed of smaller "habitats". Zone refers only to benthic community location and habitat refers only to substrate and/or cover type. Every polygon on the benthic community map will be assigned a habitat within a zone (e.g. sand in the lagoon, or sand on the bank). Zone indicates polygon location and habitat indicates composition of each benthic community delineated. Combinations of habitat and zone that are analogous to traditionally used terminology are noted where appropriate. The description of each zone and habitat includes example images. Where available, both underwater and aerial photographs are included for habitats. Aerial images are included for zones. The zone/habitat approach to the classification scheme was developed by the Caribbean Fishery Management Council; Dr. Ken Lindeman, Environmental Defense; and the NOS Biogeography Team.

Eleven mutually exclusive zones were identified from land to open water corresponding to typical insular shelf and coral reef geomorphology (Fig. 1-2). These zones include: land, vertical wall, shoreline intertidal, lagoon, reef flat, back reef, reef crest, fore reef, bank/shelf, bank/shelf escarpment, channel, and dredged (since this condition eliminates natural geomorphology). Zone refers only to each benthic community's location and does not address substrate or cover types within. For example, the lagoon zone may include patch reefs, sand, and seagrass beds; however, these are considered structural elements that may or may not occur within the lagoon zone and therefore, are not used to define it. Twenty-seven distinct and non-overlapping habitat types were identified that could be mapped by visual interpretation of remotely collected imagery. Habitats or features that cover areas smaller than the MMU were not considered. For example, sand halos surrounding patch reefs are too small to be mapped independently. Habitat refers only to each benthic community's substrate and/or cover type and does not address location on the shelf. Habitats are defined in a collapsible hierarchy ranging from four broad classes (unconsolidated sediment, submerged vegetation, coral reef and hardbottom, and other), to more detailed categories (e.g., emergent vegetation, seagrass, algae, individual patch reefs, uncolonized volcanic rock), to patchiness of some specific features (e.g., 50-90 percent cover of macroalgae).

LIST OF ZONES AND HABITATS ZONES

Land

Shoreline Intertidal

Vertical Wall*

Lagoon

Back Reef (w/ Lagoon, see barrier reef - Figure 1)

Reef Flat (w/o Lagoon, see fringing reef - Figure 2)

Reef Crest

Fore Reef

Bank/Shelf

Bank/Shelf Escarpment

Channel*

Dredged*

Unknown

^{*}not depicted in figures

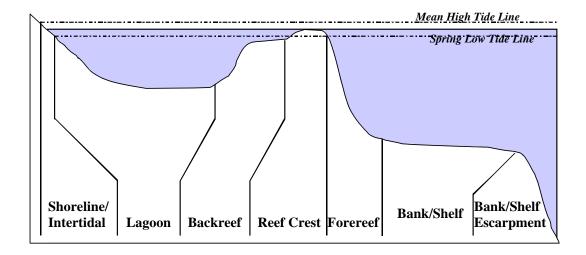


Figure 1. Barrier reef. cross-section. Reef separated from the shore by a relatively wide, deep lagoon.

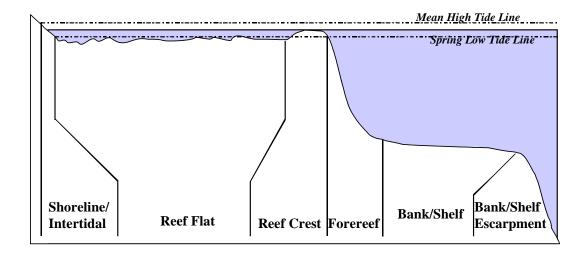


Figure 2. Fringing Reef cross-section. Reef platform is continuous with the shore.

HABITATS

Unconsolidated Sediment (0%-<10% submerged vegetation)

Mud

Sand

Submerged Vegetation

Seagrass

Continuous Seagrass (90%-100% Cover)

Patchy (Discontinuous) Seagrass (50%-<90% Cover)

Patchy (Discontinuous) Seagrass (10%-50% Cover)

Macroalgae (fleshy and turf)

Continuous Macroalgae (90%-100% Cover)

Patchy (Discontinuous) Macroalgae (50%-<90% Cover)

Patchy (Discontinuous) Macroalgae (10%-<50% Cover)

Coral Reef and Hardbottom

Coral Reef and Colonized Hardbottom

Linear Reef

Aggregated Coral

Spur and Groove

Individual Patch Reef

Aggregated Patch Reef

Scattered Coral/Rock in Unconsolidated Sediment

Colonized Pavement

Colonized Volcanic Rock/Boulder

Colonized Pavement with Sand Channels

Uncolonized Hardbottom

Reef Rubble

Uncolonized Pavement

Uncolonized Volcanic Rock/Boulder

Uncolonized Pavement with Sand Channels

Encrusting/Coralline Algae

Continuous Encrusting/Coralline Algae (90%-100% Cover)

Patchy (Discontinuous) Encrusting/Coralline Algae (50%-<90% Cover)

Patchy (Discontinuous) Encrusting/Coralline Algae (10%-<50% Cover)

Other Delineations

I and

Emergent Vegetation

Artificial

Unknown

DESCRIPTION OF ZONES AND HABITATS:

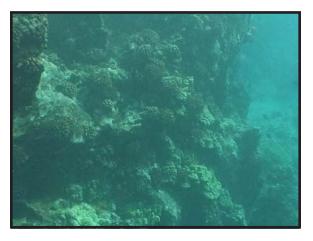
Shoreline Intertidal: Area between the mean high water line (or landward edge of emergent vegetation when present) and lowest spring tide level (excluding emergent segments of barrier reefs). Typically, this zone is narrow due to the small tidal range in the main eight Hawaiian Islands.

Typical Habitats: Mangrove, hao, sand, seagrass, and uncolonized volcanic/carbonate rock.



Vertical Wall: Area with near-vertical slope from shore to shelf or shelf escarpment. This zone is typically narrow and may not be distinguishable in remotely gathered imagery, but is included because it is recognized as a biologically important feature.

Typical Habitats: volcanic rock, algae, coral.



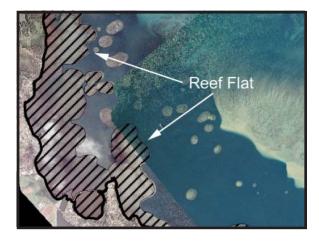
Lagoon: Shallow area (relative to the deeper water of the bank/shelf) between the shoreline intertidal zone and the back reef of a reef or a barrier island. This zone is protected from the high-energy waves commonly experienced on the bank/shelf and reef crest. If no reef crest is present there is no lagoon zone.

Typical Habitats: Sand, seagrass, algae, pavement, volcanic/carbonate rock, and patch reefs.



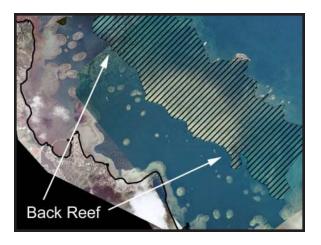
Reef Flat: Shallow (semi-exposed) area between the shoreline intertidal zone and the reef crest of a fringing reef. This zone is protected from the high-energy waves commonly experienced on the shelf and reef crest. Reef flat is typically not present if there is a lagoon zone.

Typical Habitats: Sand, reef rubble, seagrass, algae, and patch reef.



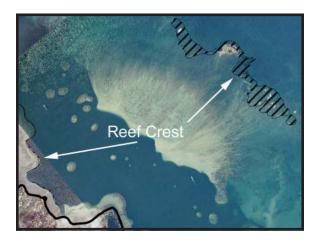
Back Reef: Area between the seaward edge of a lagoon floor and the landward edge of a reef crest. This zone is present when a reef crest and lagoon exist.

Typical Habitats: Sand, reef rubble, seagrass, algae, linear reef, and patch reef.



Reef Crest: The flattened, emergent (especially during low tides) or nearly emergent segment of a reef. This zone lies between the back reef and fore reef zones. Breaking waves will often be visible in aerial images at the seaward edge of this zone.

Typical Habitats: Reef rubble, linear reef., and aggregated coral.



Zones

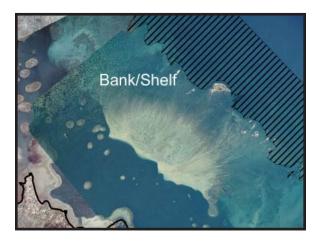
Fore Reef: Area from the seaward edge of the reef crest that slopes into deeper water to the landward edge of the bank/shelf platform. Features not forming an emergent reef crest but still having a seaward-facing slope that is significantly greater than the slope of the bank/shelf are also designated as fore reef (Fig. 2).

Typical Habitats: Linear reef and Spur and Groove.



Bank/Shelf: Deep water area (relative to the shallow water in a lagoon) extending offshore from the seaward edge of the fore reef to the beginning of the escarpment where the insular shelf drops off into deep, oceanic water. The bank/shelf is the flattened platform between the fore reef and deep open ocean waters or between the shoreline/intertidal zone and open ocean if no reef crest is present.

Typical Habitats: Sand, patch reefs, algae, seagrass, linear reef, colonized and uncolonized pavement, colonized and uncolonized pavement with sand channels, and other coral reef habitats.



Shelf Escarpment: The edge of the bank/shelf where depth increases rapidly into deep, oceanic water. This zone begins at approximately 20 to 30 meters depth, near the depth limit of features visible in aerial images. This zone extends well into depths exceeding those that can be seen on aerial photographs and is intended to capture the transition from the shelf to deep waters of the open ocean.

Typical Habitats: Sand, linear reef, and spur and groove.





Channel: Naturally occurring channels that often cut across several other zones.

Typical Habitats: Sand, mud, uncolonized pavement.

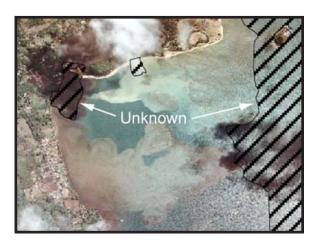


Dredged: Area in which natural geomorphology is disrupted or altered by excavation or dredging.

Typical Habitats: Sand, mud.



Unknown: Zone uninterpretable due to turbidity, cloud cover, water depth, or other interference.

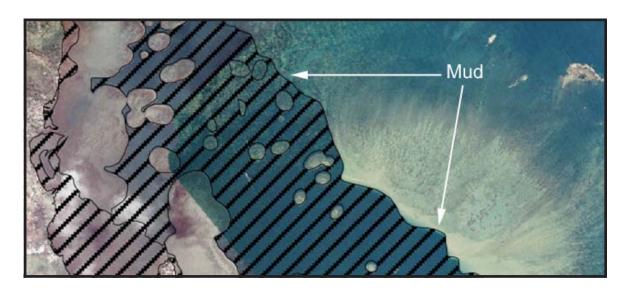


Mud

Unconsolidated Sediment: Unconsolidated sediment with less than 10 percent cover of submerged vegetation.

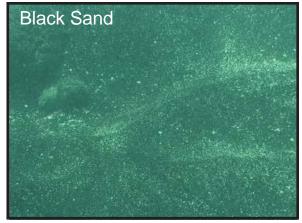
Mud: Fine sediment often associated with river discharge and buildup of organic material in areas sheltered from high-energy waves and currents.





Sand

Sand: Coarse sediment typically found in areas exposed to currents or wave energy.





Seagrass

Submerged Vegetation: Greater than 10 percent cover of submerged vegetation in unspecified substrate type (usually sand, mud, or hardbottom).

Seagrass: Habitat with 10 percent or more cover of seagrass (e.g., *Halophila sp.*).

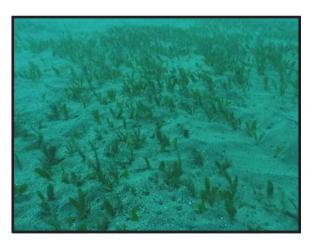
Continuous Seagrass: Seagrass covering 90 percent or more of the substrate. May include blowouts of less than 10% of the total area that are too small to be mapped independently (less than the MMU). This includes continuous beds of any shoot density (may be a continuous sparse or dense bed).

Patchy Seagrass: Discontinuous seagrass with breaks in coverage that are too diffuse or irregular, or result in isolated patches of seagrass that are too small (less than the MMU) to be mapped as continuous seagrass.

Patchy Seagrass (50%-90% cover)
Patchy Seagrass (10%-50%

Representative Species: *Halophila sp.*

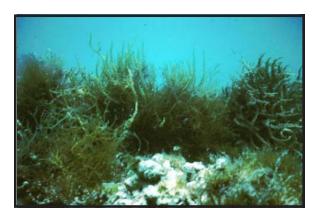
cover)



Macroalgae

Macroalgae: An area with 10 percent or greater coverage of any combination of numerous species of red, green, or brown macroalgae. Usually occurs in shallow backreef and deeper waters on the bank/shelf zone. High relief (hardbottom) habitats takes precedence over macroalgae cover.

Continuous Macroalgae: Macroalgae covering 90 percent or greater of the substrate. May include blowouts of less than 10 percent of the total area that are too small to be mapped independently (less than the MMU). This includes



continuous beds of any density (may be a continuous sparse or dense bed).

Patchy Macroalgae: Discontinuous macroalgae with breaks in coverage that are too diffuse or irregular, or result in isolated patches of macroalgae that are too small (smaller than the MMU) to be mapped as continuous macroalgae.

Patchy Macroalgae (50%-<90% cover) Patchy Macroalgae (10%-<50% cover)

Representative Species:

Dictyosphaeria spp.







Coral Reef and Hardbott

Linear Reef

Coral Reef and Hardbottom: Hardened substrate of unspecified relief formed by the deposition of calcium carbonate by reef building corals and other organisms (relict or ongoing) or existing as exposed bedrock or volcanic rock.

Coral Reef and Colonized Hardbottom:

Substrates formed by the deposition of calcium carbonate by reef building corals and other organisms. Habitats within this category have some colonization by live coral, unlike the uncolonized hardbottom category.





Linear Reef: Linear coral formations that are oriented parallel to shore or the shelf edge. These features follow the contours of the shore/shelf edge. This category is used for such commonly used terms as fore reef, fringing reef, and shelf edge reef.



Aggregated Coral

Aggregated Coral: Coral-dominated formations with high relief and structural complexity. Often serve same role as linear reef habitat in fringing reef systems where the reef crest is relatively unorganized.



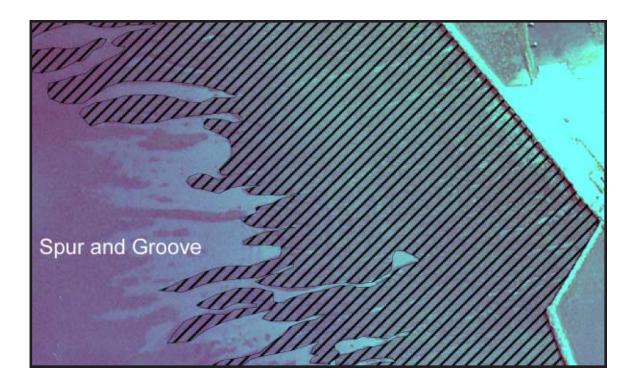




Spur and Groove

Spur and Groove: Habitat having alternating sand and coral formations that are oriented perpendicular to the shore or bank/shelf escarpment. The coral formations (spurs) of this feature typically have a high vertical relief relative to pavement with sand channels (see below) and are separated from each other by 1-5 meters of sand or bare hardbottom (grooves), although the height and width of these elements may vary considerably. This habitat type typically occurs in the fore reef or bank/shelf escarpment zone.

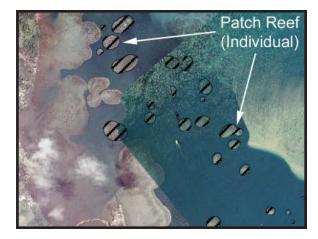




Patch Reefs

Patch Reef(s): Coral formations that are isolated from other coral reef formations by sand, seagrass, or other habitats and that have no organized structural axis relative to the contours of the shore or shelf edge.

Individual patch reef: Distinctive single patch reefs that are larger than or equal to the MMU.



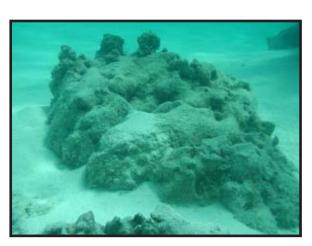
Aggregate patch reefs: Clustered patch reefs that individually are too small (less than the MMU) or are too close together to map separately.



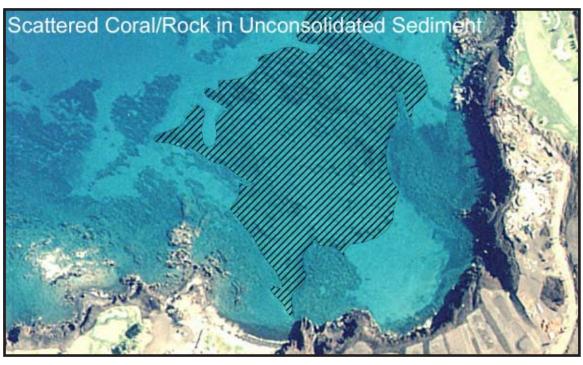


Scattered Coral/Rock in Unconsolidated Sediment

Scattered Coral/Rock in Unconsolidated Sediment: Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be delineated individually (i.e. smaller than individual patch reef).

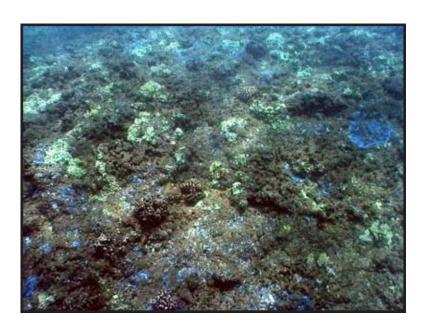


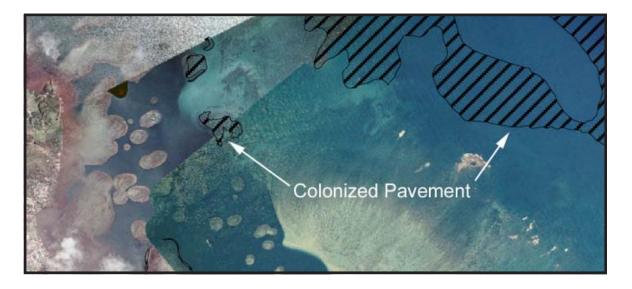




Colonized Pavement

Colonized Pavement: Flat, low-relief, solid carbonate rock with coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that are dense enough to begin to obscure the underlying surface.





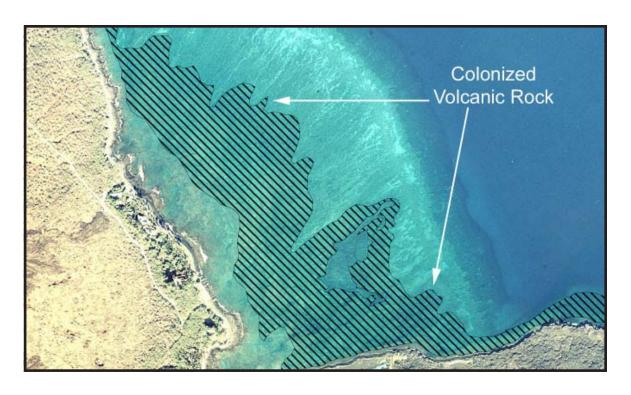
Coral Reef and Hardbottom

Colonized Volcanic Rock/Boulder

Colonized Volcanic Rock/Boulder: Solid volcanic rock that has coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that begins to obscure the underlying surface.





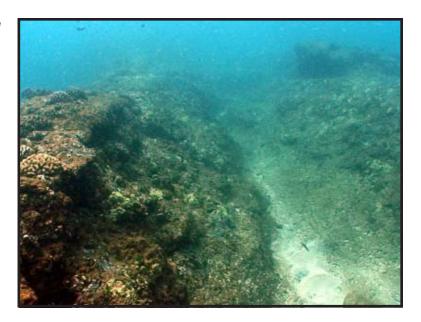


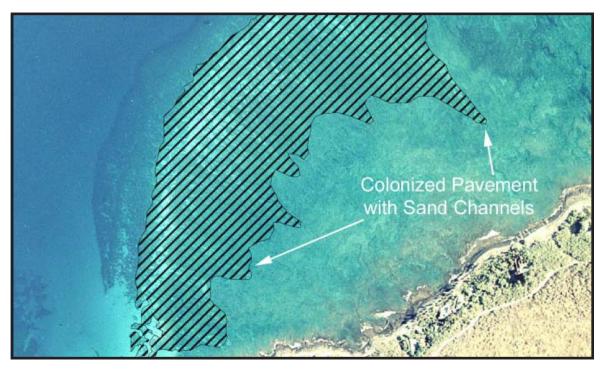
Colonized Pavement with Sand Channels

Colonized Pavement with Sand Channels: Habitat having alternating sand and colonized pavement formations that are oriented perpendicular to the shore or bank/shelf escarpment. The sand channels of this feature have low vertical relief relative to spur and groove formations. This habitat type occurs in areas exposed to moderate wave surge such as the bank/shelf zone.

Representative Species/Live Coral Community:

Porites compressa Porites lobata Montipora spp. Pocillopora meandrina





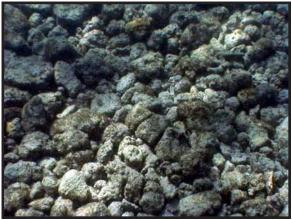
Coral Reef and Hardbotton

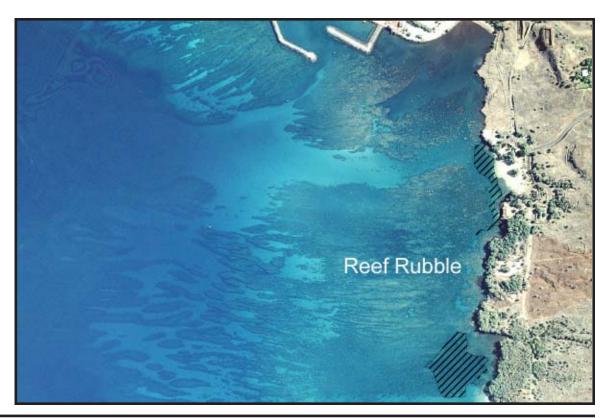
Reef Rubble

Uncolonized Hardbottom: Hard substrate composed of relict deposits of calcium carbonate or exposed volcanic rock.

Reef Rubble: Dead, unstable coral rubble often colonized with filamentous or other macroalgae. This habitat often occurs landward of well developed reef formations in the reef crest or back reef zone.







Uncolonized Pavement

Uncolonized Pavement: Flat, low relief, solid carbonate rock that is often covered by a thin sand veneer. The pavement's surface often has sparse coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that does not obscure the underlying surface.

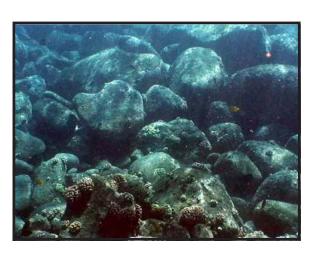




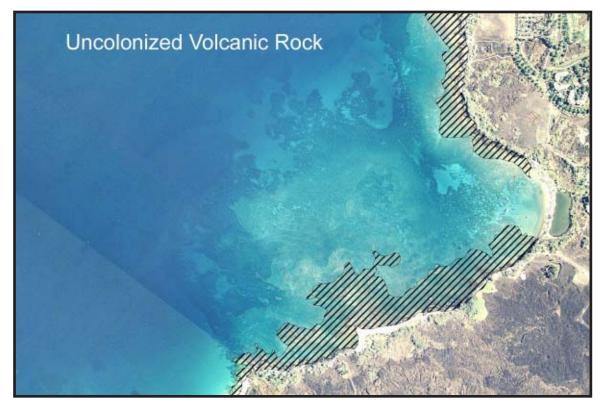


Uncolonized Volcanic Rock/Boulder

Uncolonized Volcanic Rock/Boulder: Exposed volcanic rock that has sparse coverage of macroalgae, hard coral, zoanthids and other sessile invertebrates that does not obscure the underlying surface.

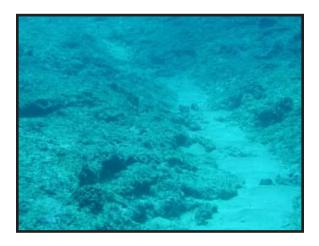


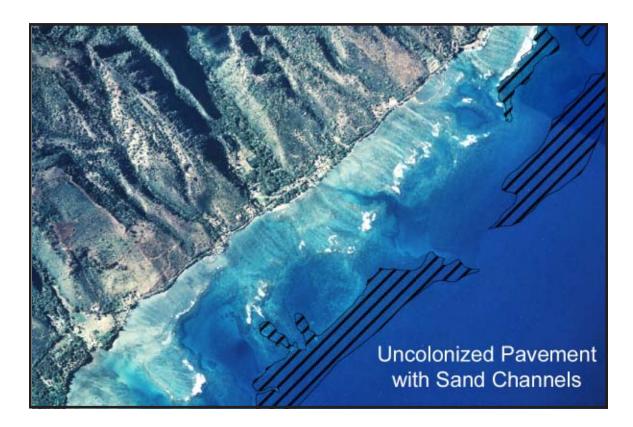




Uncolonized Pavement with Sand Channels

Uncolonized Pavement with Sand Channels: Habitat having alternating sand and uncolonized pavement formations that are oriented perpendicular to the shore or bank/shelf escarpment. The sand channels of this feature have low vertical relief relative to spur and groove formations. This habitat type occurs in areas exposed to moderate wave surge such as the bank/shelf zone.





Encrusting Coralline Algae

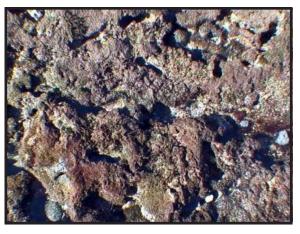
Encrusting/Coralline Algae: An area with 10 percent or greater coverage of any combination of numerous species of encrusting or coralline algae. May occur in shallow backreef, relatively shallow waters on the bank/shelf zone, and at depth.

Continuous Encrusting/Coralline Algae: Encrusting/coralline algae covering 90 percent or more of the substrate.

Patchy Encrusting/Coralline Algae: Discontinuous encrusting/coralline algae with breaks in coverage that are too diffuse or irregular, or result in isolated patches of coralline algae that are too small (less than the MMU) to be mapped as continuous coralline algae.

Patchy Encrusting/Coralline Algae (50%-<90% cover) Patchy Encrusting/Coralline Algae (10%-<50% cover)

Representative Species: Porolithon gardineri







Other Delineations

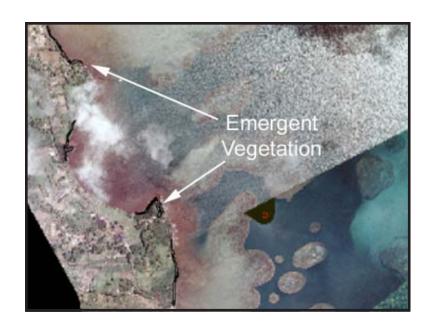
Emergent Vegetation

Other Delineations:

Emergent Vegetation: Emergent habitat composed primarily of *Rhizophora* mangle (red mangrove) and hao trees. Generally found in areas sheltered from high-energy waves. This habitat type is usually found in the shoreline/intertidal, back reef, or barrier reef crest zone.



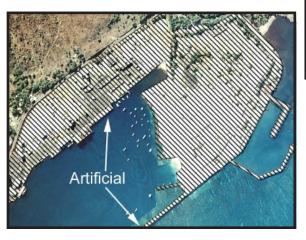


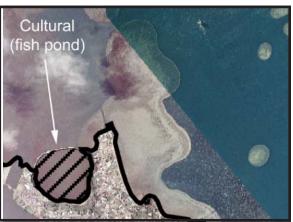


Other Delineations

Artificial

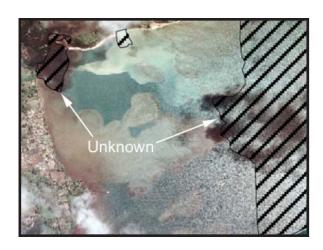
Artificial: Man-made habitats such as submerged wrecks, large piers, submerged portions of rip-rap jetties, and the shoreline of islands created from dredge spoil. Includes active and remnant fish ponds walled off from the open ocean along the shoreline, often along a reef crest.





Unknown

Unknown: Bottom type unknown due to turbidity, cloud cover, water depth, or other interference.





REFERENCES

- Allee, R.J., and 11 co-authors. 2000 Draft. Marine and Estuarine Ecosystem Classification. National Marine Fisheries Service. Office of Habitat Conservation. Silver Spring, MD. 41 p.
- Beets, J., L. Leewand, and E.S. Zullo. 1986. Marine community descriptions and maps of bays within the Virgin Islands National Park/Biosphere Reserve. Biosphere Reserve Research Report No. 2, MAB, NPS, DOI. 118 pp.
- Boulon, R.H. 1986. Distribution of fisheries habitats within the Virgin Islands Biosphere Reserve. Biosphere Reserve Research Report No. 8, MAB, NPS, DOI. 56 pp.
- Chauvaud, S., C.Bouchon, and R. Maniere. 1998. Remote sensing techniques adapted to high resolution mapping of tropical coastal marine ecosystems (coral reefs, seagrass beds, and mangrove). Int.J.Remote.Sens. 19(18):3525-3639.
- Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute and National Oceanic and Atmospheric Administration. 1998. Benthic Habitats of the Florida Keys. FMRI Technical Report No. TR-4. 52 pp.
- Gulko, D. 1998. Hawaiian Coral Reef Ecology. Mutual Publishing. Honolulu, HI. 245 p.
- Holthus, P.F., and Maragos, J.E., 1995. Marine ecosystem classification for the tropical island Pacific. In: Maragos, J.E., Peterson, M.N.A., Eldredge, L.G., Bardach, J.E., Takeuchi, H.F. Eds.), Marine and Coastal Biodiversity in the Tropical Island Pacific Region, East-West Center, Honolulu, pp 239-278.
- Kruer, C. 1995. Mapping and characterizing seagrass areas important to manatees in Puerto Rico-Benthic Communities Mapping and Assessment. Report Prepared for U.S. Dol, Nat. Biol. Serv., Sirenia Project, Order No. 83023-5-0161. 14 pp.
- Lindeman, K.C., G.A. Diaz, J.E. Serafy, and J.S. Ault. 1998. A spatial framework for assessing cross-shelf habitat use among newly settled grunts and snappers. Proc. Gulf Carib. Fish. Inst. 50:385-416.
- Mumby, P.J., A.R.Harborne, and P.S. Raines. 1998. Draft Classification Scheme for Marine Habitats of Belize. UNDP/GEF Belize Coastal Zone Management Project. 44 pp.
- Kendall, M.S., C.R. Kruer, K.R. Buja, J.D. Christensen, M. Finkbeiner, and M.E. Monaco. 2001. Methods used to map the benthic habitats of Puerto Rico and the U.S. Virgin Islands. National Ocean Service, Center for Coastal Monitoring and Assessment, Biogeography Program, Silver Spring, MD. 45pp.
- Reid, J.P., and C.R. Kruer. 1998. Mapping and characterization of nearshore benthic habitats around Vieques Island, Puerto Rico. Report to U.S. Navy. U.S. Geological Survey/BRD, Sirenia Project, Gainesville Florida. 11pp.
- Sheppard, C.R., K. Matheson, J.C. Bythel, P.Murphy, C.B.Myers, and B.Blake. 1998. Habitat mapping in the Caribbean for management and conservation: Use and Assessment of Aerial Photography. Aquat.Cons. 5:277-298
- State of Hawaii 1981. O'hau Costal Zone Atlas: Hawaii Coral Reef Inventory Island of O'hau. Part C.1. Harbors Division Dept. of Transportation. Honolulu, HI.

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